ASTONJADRO

pISSN 2302-4240
eISSN 2655-2086

Volume 14, Issue 3, September 2025, pp.0737-0744
DOI: http://dx.doi.org/10.32832/astonjadro.v14i3.17921 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Analysis of the Utilization of Hair Fibers as an Eco-Friendly Concrete Construction Material

M. Iqbal[1], Erniati Bachtiar[2], Sri Gusty[1], Poppy Indrayani[1], Ismail Marzuki[3], Muhammad Chaerul[1]

[1]Master of Infrastructure and Material Engineering, Fajar of University, Makassar, INDONESIA
[2]Civil Engineering Department, Fajar University, Makassar, INDONESIA
[3]Chemical Engineering Department, Fajar University, Makassar, INDONESIA

E-mail: muhammadiqbal28398@gmail.com, erni@unifa.ac.id

| Submitted: October 03, 2024 | Revised: December 22, 2024 | Accepted: December 30, 2024 |

| Published: September 18, 2025 |

ABSTRACT

The handling of human hair waste is still not optimal, as it is often discarded or burned, leading to environmental pollution. This research aims to utilize human hair waste as a mixture in normal concrete, resulting in a fiber-reinforced concrete product with marketable value, providing a more beneficial use compared to simply being disposed of or burned. The purpose of this study is to analyze the mechanical properties of concrete using human hair fibers. The mechanical properties to be analyzed include compressive strength, tensile splitting strength, and flexural strength. This research is based on laboratory experiments. The variations in the amount of fiber used in the study are 0.25%, 0.5%, 1%, and 1.5% of the cement weight in the concrete mix. Based on the results of mechanical property testing, it can be concluded that the optimal addition of 1% human hair fibers yielded a compressive strength of 22.86 MPa, tensile splitting strength of 2.69 MPa, and flexural strength of 4.13 MPa.

Keywords: concrete; compressive strength; split tensile strength; flexural strength; hair fiber.

INTRODUCTION

Indonesia has experienced rapid growth in infrastructure, particularly in civil engineering, such as the construction of buildings, bridges, and roads. The use of concrete as a construction material has increased due to its ability to be mixed with other materials, enhancing its strength and durability. Concrete, which is composed of cement, aggregates, water, and additives, continues to innovate, including the development of fiber-reinforced concrete designed to reduce cracking and improve tensile strength, especially under various weather conditions [1].

The demand for concrete in Indonesia is expected to continue rising, especially for infrastructure projects such as roads, bridges, and buildings. This indicates a growing need for fiber-reinforced concrete, which is mixed with fibers to minimize microcracks and provide additional strength. Climate change and temperature fluctuations affect concrete durability, making innovation in concrete development crucial to meet the evolving construction needs [2].

Waste and litter have become a global concern, prompting many researchers to focus on how to reuse and repurpose these materials. One abundant type of waste is plastic, which can be utilized as a component in concrete, particularly as an artificial coarse aggregate [3]. Interestingly, the large amount of hair waste that is often discarded or burned can be utilized as an additive in concrete. This waste has the potential to enhance the tensile strength of concrete [4].

Human hair possesses high tensile strength due to its structure, which is composed of keratin. Research has shown that hair can withstand significant loads, and its physical and chemical properties provide good resistance to stress [5]. Understanding these characteristics reveals the potential to repurpose hair waste for use in construction, such as in concrete mixtures, transforming it from a harmful waste into a valuable resource.

Several studies on concrete using human hair fibers have shown varied results [6]-[8]. he addition of human hair waste to concrete mixtures can improve the mechanical properties, particularly in terms of flexural strength, although test results indicate variability in strength. Previous research demonstrated that the tensile splitting strength of concrete with hair fibers varies depending on the proportion used. This suggests that further research is needed to optimize the use of hair waste in construction, making it more beneficial and sustainable.

Research on concrete with human hair fibers by [4], showed that the tensile splitting strength for concrete with human hair fibers at 0%, 5%, 10%, and 15% variations were 2.87 MPa, 3.72 MPa, 2.65 MPa, and 1.91 MPa, respectively.

The highest tensile strength was observed in the 5% fiber sample. However, the compressive strength for the 5% fiber variation was 17.39 MPa, lower than that of the normal concrete (0% variation) at 31.39 MPa. Therefore, this study suggests further investigation into adding hair fibers at proportions below 5% in concrete mixtures. The study analyzes the mechanical properties of concrete with added human hair fibers, specifically focusing on compressive strength, tensile splitting strength, and flexural strength [9]–[11].

Good fine aggregate usually comes from natural river sand or sand from stone crushing, clean and free from organic impurities, clay, and salt. The grain size must pass through a standard 4.75 mm sieve [12]. Uniform sand gradation is crucial because it affects the workability of the concrete. Sand that is too fine can increase water requirements, while sand that is too coarse can reduce the homogeneity of the mix. Therefore, selecting sand with a good gradation and low silt content will produce denser and stronger concrete [13], [14].

Coarse aggregate is generally crushed stone with sharp corners, is hard, non-porous, and does not contain substances that can react negatively with cement. The maximum grain size is usually determined by the thickness of the structural element or the spacing between the reinforcement bars, generally no more than 20–40 mm. The selected coarse aggregate must be well-graded so that the voids between the grains can be filled by the cement paste and fine aggregate, resulting in dense concrete with low porosity. The shape of the aggregate is also important; Round aggregate from river gravel is easier to work with, but concrete from sharp-angled crushed stone usually provides higher strength due to good adhesion to the cement paste [15], [16].

RESEARCH METHODS

Materials

The materials used in this study are local materials. The components include gravel, sand, water, cement, and human hair waste.

Peralatan

The equipment used in this study includes a scale with a sensitivity of 0.1 grams, a tensile testing machine for reinforcement, an oven, a sieve shaker, a set of sieves, a mixer, molds, a Universal Testing Machine (UTM), a Hydraulic Concrete Beam (HCB), a cement scoop, a measuring cup, a dish, a brush, a soaking tub, and other supporting tools.

Research Procedure

a. Mix Design & Sample Preparation

Before creating the research samples, tests are conducted on the material characteristics to ensure that the materials are suitable for use as concrete components. Based on the aggregate test results, a mix design calculation is performed to determine the appropriate mixture composition using the DOE (Department of Environment) method. After obtaining the correct composition, the concrete samples are then made according to the planned quantity.

Standard Concrete Sample

he prepared materials are placed into the mixer. First, gravel and sand are added, followed by cement. Once these three materials are mixed thoroughly, water is added gradually while continuously stirring until all the components are homogeneously combined. This concrete sample is used as a standard without the addition of human hair fibers and is referred to as normal concrete.

Concrete Sample with Added Human Hair

pISSN 2302-4240
eISSN 2655-2086
Volume 14, Issue 3, September 2025, pp.0737-0744
DOI: http://dx.doi.org/10.32832/astonjadro.v14i3.17921 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

The samples are similar to the normal concrete, except that human hair fibers are added. Each variation of the hair fiber amount consists of three samples. The amounts of hair fibers used include four variations: 0.25%, 0.5%, 1%, and 1.5%.

Before casting the test specimens, a slump test is conducted. The results indicate that the slump test values range from 80 cm to 100 cm. These values meet the standard requirements for a good mixture, which should be between 7.50 cm and 15.00 cm.

b. Curing of Concrete

After the test specimens are removed from the molds, they undergo a curing process. This is done by immersing the specimens in a soaking tub. The purpose of curing concrete is to keep the surface moist, ensuring that the hydration process occurs effectively and that hardening takes place without any cracks. This process helps guarantee the quality of the concrete.

c. Testing

This study involves three types of mechanical tests: compressive strength testing, tensile splitting strength testing, and flexural strength testing of concrete. These tests are performed on concrete samples that have cured for 28 days, following ASTM standards (ASTM C39/C39M-21, 2021; ASTM C496/C496M-17, 2017; ASTM C78-09, 2009).

This step represents a laboratory experimental study in the production of normal concrete with hair waste fibers, as illustrated in Figure 1.

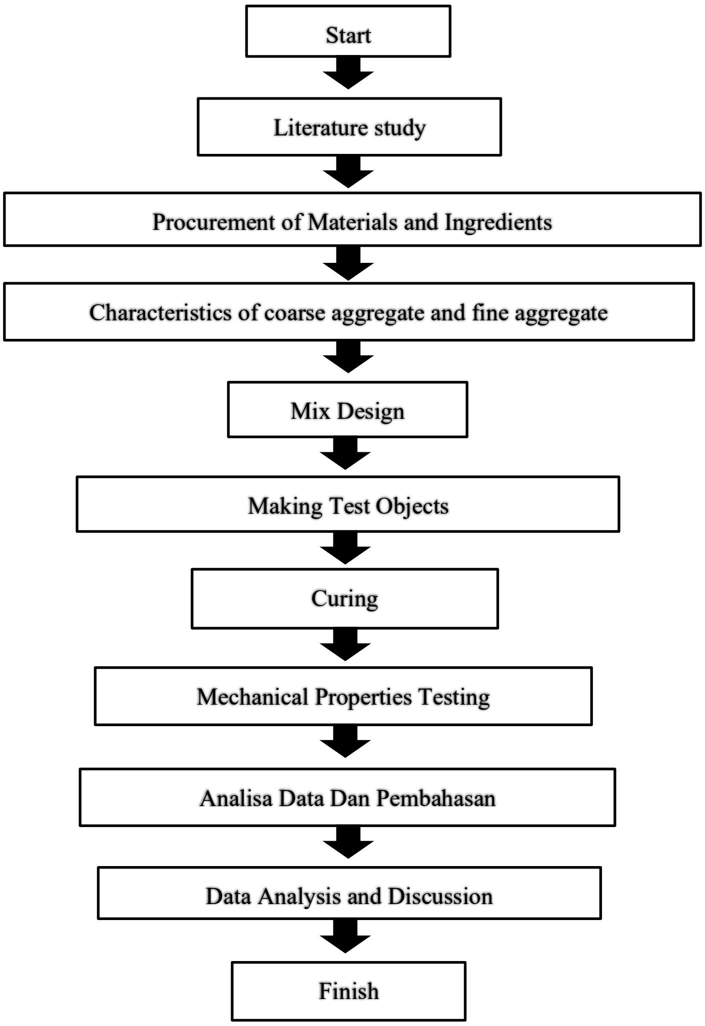

Figure 1. Research Flow

RESEARCH RESULTS AND DISCUSSION

Aggregate Characteristics

The fine and coarse aggregate materials used in this study were sourced from Takalar. The characterization tests for the fine aggregate were conducted in the laboratory of the Civil Engineering Department at Universitas Fajar Makassar. The testing process is detailed in Table 1 and Table 2 below.

Table 1. Fine Aggregate Examination Results

No	Test Item	Result	Interval
1	Mud Content (%)	4,89	0,2 – 5
2	Water content (%)	3,14	3 - 5
3	Volume Weight		
	a. Lose condition (kg/ltr)	1,7083	1,4 - 1,9
	b. Compacted condition (kg/ltr)	1,7520	1,4 - 1,9
4	Specific gravity		
	a. Bulk Specific gravity (gr)	2,72	1,60 - 3,30
	b. Apparent specific gravity (gr)	2,63	1,60 - 3,31
	c. Surface Specific gravity (gr)	2,66	1,60 - 3,32
	d. Absorbsi (%)	1,26	0,2 - 2
5	Fineness Modulus	3,00	2,3 - 3,1
6	Organic content	No.2	<No.3

Table 2. Results of Coarse Aggregate

No	Test Item	Result of examination	Interval
1	Mud Content (%)	0,4	Maks 1
2	Water content (%)	1,33	0,5-2
3	Volume Weight		
	a. Lose condition (kg/ltr)	1,672	1,6 - 1,9
	b. Compacted condition (kg/ltr)	1,702	1,6 - 1,9
4	Specific gravity		
	a. Bulk Specific gravity (gr)	2,68	1,60 - 3,33
	b. Apparent specific gravity (gr)	2,49	1,60 - 3,34
	c. Surface Specific gravity (gr)	2,56	1,60 - 3,35
	d. Absorbsi (%)	2,875	Maks 4
5	Fineness Modulus	6,63	6 - 7,1
6	Abrasion (%)	40	Maks 50

The characteristics of fine and coarse aggregates presented in Table 1 and Table 2 indicate that the materials meet the SNI (Indonesian National Standard). Therefore, these aggregates can be utilized as mixing materials in concrete production.

Compressive Strength of Concrete

The compressive strength of concrete is defined as the amount of load per unit area that causes the test specimen to fail due to the compressive forces exerted by the concrete testing machine. The compressive strength test procedure follows (ASTM C39/C39M-21, 2021). The compressive strength of concrete is determined by the ratio of coarse aggregate, fine aggregate, cement, water, and the type of concrete mix (Dipohusodo, 1996b). The water-to-cement ratio is also a crucial factor in determining the strength of concrete. The compressive strength testing was conducted at 28 days of curing using cylindrical specimens with a diameter of 10 cm and a height of 20 cm, which were

pISSN 2302-4240
eISSN 2655-2086
Volume 14, Issue 3, September 2025, pp.0737-0744
DOI: http://dx.doi.org/10.32832/astonjadro.v14i3.17921 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

soaked in freshwater. The average compressive strength results for the concrete specimens soaked in freshwater are illustrated in Figure 2.

Based on Figure 2, the results of the compressive strength testing indicate that concrete with 0% fiber addition has an average compressive strength of 20.58 MPa, which aligns with the planned mix design. There is an insignificant decrease in compressive strength at the 0.25% variation, with an average value of 21.56 MPa. Subsequently, there is an increase in compressive strength at the 0.5% variation, reaching an average of 23.03 MPa. However, for concrete with a 1% addition of human hair fibers, the compressive strength decreases to 22.86 MPa, where the addition of hair in one cylindrical test specimen weighed 0.011 grams. At the 1.5% variation, the compressive strength also declines to an average of 21.88 MPa. Nevertheless, the concrete with the 1% human hair fiber variation achieves the highest compressive strength compared to the other variations. This is attributed to the binding properties of hair fibers, which create different crack patterns compared to normal concrete.

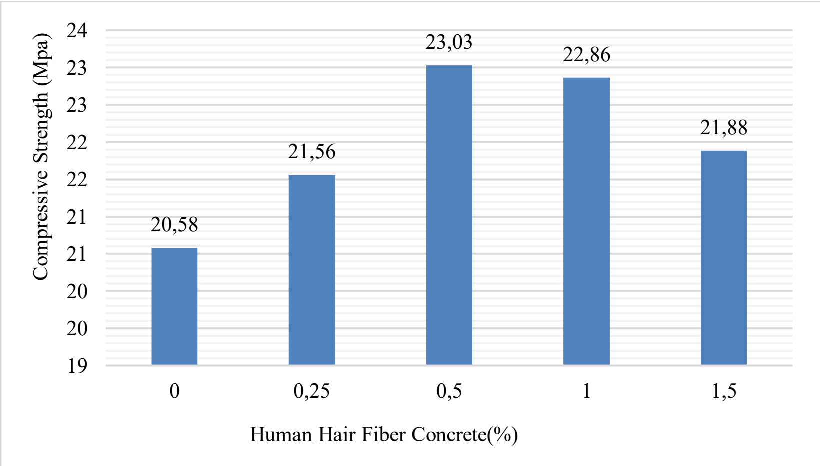

Figure 2. Compressive Strength Test Results of Concrete

Tensile Splitting Strength

The tensile splitting strength test was conducted using cylindrical molds measuring 10 cm x 20 cm to evaluate the shear resistance of the structural components. This testing follows ASTM standards (ASTM C496/C496M-17, 2017). The test involved 15 cylindrical samples with variations of human hair fibers at 0%, 0.25%, 0.5%, 1%, and 1.5% of the weight of the cement, with each variation consisting of 3 samples for tensile splitting strength testing. The maximum tensile splitting strength was achieved when the cylinders subjected to pressure from the Universal Testing Machine (UTM) experienced cracking due to the maximum load applied.

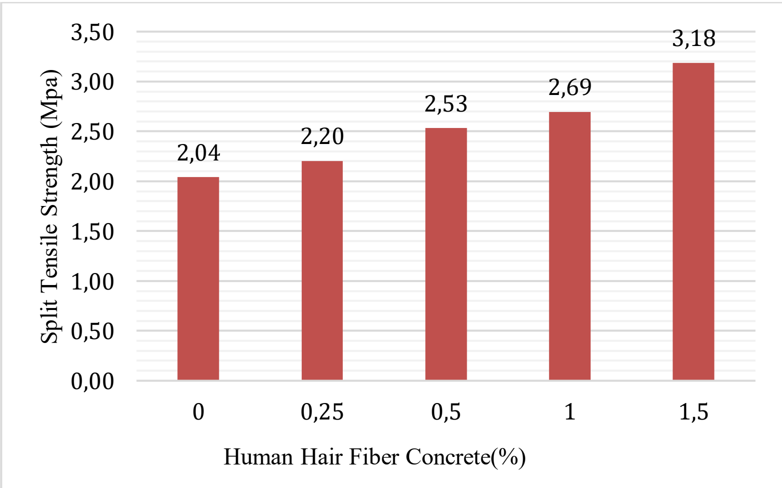

Figure 3. Tensile Splitting Strength Test Results of Concrete

Based on the results shown in Figure 3, it can be concluded that the addition of human hair fibers to the concrete enhances the tensile splitting strength. This is evident from the comparison between concrete without any hair fiber addition (0% variation) and concrete containing hair fibers. In the case of concrete with a 0% variation, the tensile splitting strength is recorded at 2.04 MPa, whereas at the 0.25% variation, it increases to 2.20 MPa. The tensile splitting strength continues to rise with the increasing percentage of hair fiber addition, reaching a peak value of 3.18 MPa at the 1.5% variation, which is the highest value in this testing. This increase is attributed to the binding properties of the hair fibers within the concrete.

Flexural Strength of Concrete

The flexural strength of concrete was tested using simply supported beams measuring 15 x 15 x 60 cm with a two-point loading arrangement. The flexural strength testing follows ASTM standards(ASTM C78-09, 2009) ASTM. The purpose of this test is to determine the flexural strength of the concrete. Additionally, this test provides the maximum load capacity that the beam can withstand before failure, as well as the amount of deformation that occurs during loading, using a Hydraulic Concrete Beam testing machine. A total of 15 beam samples were tested, with variations of human hair fibers at 0%, 0.25%, 0.5%, 1%, and 1.5%.

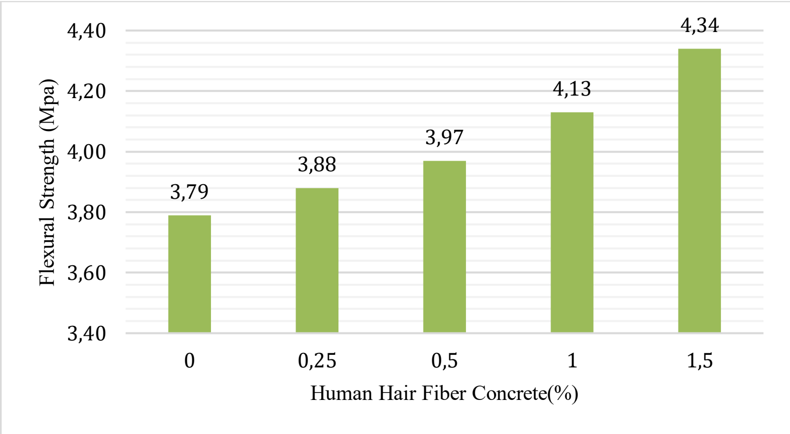

Figure 4. Flexural Strength of Concrete

Based on the results shown in Figure 4, the flexural strength testing indicates that the addition of human hair fibers to the concrete improves its flexural strength. This improvement is evident in the comparison between concrete without any hair fiber addition (0% variation) and concrete containing hair fibers. In the 0% variation, the flexural strength is recorded at 3.79 MPa, while in the 0.25% variation, it increases to 3.88 MPa. The flexural strength continues to rise, reaching 4.13 MPa at the 1% variation and 4.34 MPa at the 1.5% variation, which represents the highest value recorded in this testing.

Comparison of Mechanical Testing of Concrete

The comparison of mechanical properties among compressive strength, tensile splitting strength, and flexural strength can be seen in Table 3 and Figure 5.

Tabel 3. Results of Mechanical Properties Testing of Concrete

Variation of Human Hair Fiber (%)	Compressive Strength (MPa)	Tensile Splitting Strength (MPa)	Flexural Strength (MPa)
0%	20,58	2,04	3,79
0,25%	21,56	2,20	3,88
0,5%	23,03	2,53	3,97
1%	22,86	2,69	4,13
1,5%	21,88	3,18	4,34

Source: Results of Concrete Mechanical Properties Testing

pISSN 2302-4240
eISSN 2655-2086
Volume 14, Issue 3, September 2025, pp.0737-0744
DOI: http://dx.doi.org/10.32832/astonjadro.v14i3.17921 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Figure 5 illustrates the comparison of compressive strength, flexural strength, and tensile splitting strength of concrete with the addition of human hair fibers. As we know, the mechanical properties of compressive strength, tensile splitting strength, and flexural strength are interrelated. The relationship between compressive strength and flexural strength is important: as the compressive strength increases, the flexural strength tends to increase as well [3] below.

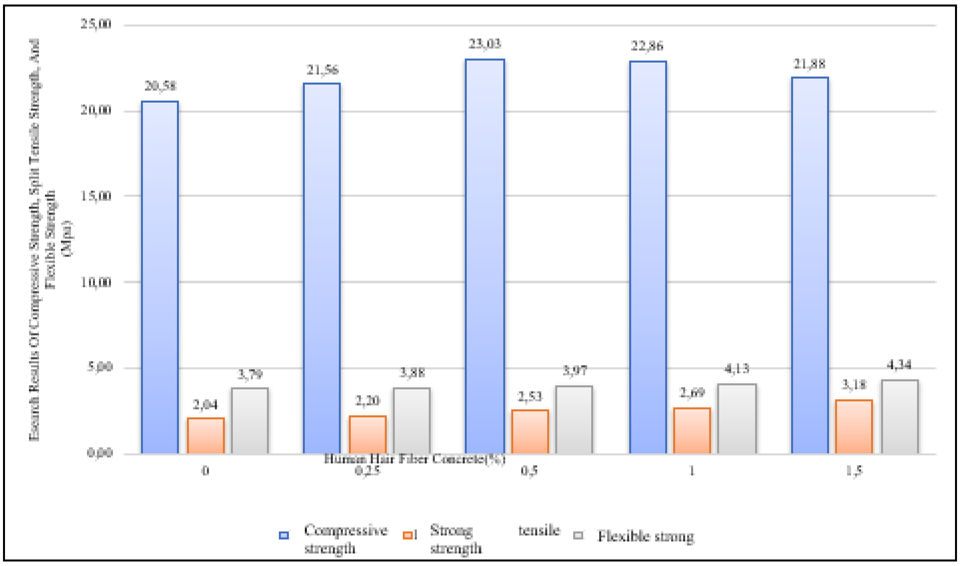

Figure 5. Results of Comparison of Mechanical Properties Testing of Concrete

CONCLUSION

Based on the test data obtained from normal concrete and concrete with human hair fibers analyzed after 28 days of immersion in fresh water, the study concludes that: 1) the compressive strength of concrete with variations of human hair fiber addition at 0%, 0.25%, 0.5%, 1%, and 1.5% of the cement weight are 20.58 MPa, 21.56 MPa, 23.03 MPa, 22.86 MPa, and 21.88 MPa, respectively. The highest compressive strength was achieved with a 1% addition of human hair fibers, reaching 23.03 MPa, 2) the results of the tensile splitting strength tests indicate that the addition of human hair fibers can enhance the tensile splitting strength of concrete. The tensile splitting strengths are as follows: 0% is 2.04 MPa, 0.25% is 2.20 MPa, 0.5% is 2.53 MPa, 1% is 2.69 MPa, and 1.5% is 3.18 MPa. The increase in tensile splitting strength corresponds with the addition of human hair fibers, peaking at 1.5%, 3) flexural strength improvement begins at 0% with a value of 3.79 MPa, increasing to 3.88 MPa at 0.25%. At 0.5%, the flexural strength reaches 3.97 MPa, followed by 4.13 MPa at 1%, and the highest value of 4.34 MPa at 1.5%. These results indicate that the addition of human hair fibers positively influences and enhances the flexural strength of concrete, 4) the 1% variation showed the best results, with a compressive strength of 22.86 MPa, tensile splitting strength of 2.69 MPa, and flexural strength of 4.13 MPa. Based on the compressive strength results, concrete with the 1% variation falls into the medium-quality concrete category, equivalent to concrete grade K-275, suitable for applications in structures such as house slabs, foundations, and two-story buildings.

REFERENCES

[1] Suwarno, A., & Sudarmono. (2015). Kajian Penggunaan Limbah Plastik Sebagai Campuran Agregat Beton. *Wahana Teknik Sipil*, *1*(20).

[2] Dipohusodo, I. (1996a). *Manajemen Proyek & Konstruksi*. Kanisius.

[3] Bachtiar, E., Ihsan, M., Irfan, U. R., Setiawan, A., Makbul, R., Setiawan, A. M., & Tata, A. (2022). Utilization of Artificial Coarse Aggregate from Polyethylene Terephthalate Plastic Waste in Concrete. *International Review of Civil Engineering*, *13*(1), 19–30. https://doi.org/10.15866/irece.v13i1.21122

[4] Iqbal, M., Erdawaty, & Bachtiar, E. (2022). Study On The Potential Utilization Of Human Hair Waste As Fiber In Concrete. *Journal of Applied Civil and Environmental Engineering*,

2(1).

[5] Jimmy, G., & Vandana. (2016). Effects on Compressive Strength of Concrete by use of Natural Human Hair as Fibrous Material. *Journal of Civil Engineering and Environmental Technology*, *3*.

[6] G.Sreevani, S., Ajitha, mt. B., & et all. (2017). *Human Hair as Fibre Reinforcement in Concrete. , India*. JNT University, Anantapur.

[7] D, J., & A, K. (2011). Hair Fibre Reinforced Concrete. *Research Journal of Recent Sciences*, *1*.

[8] Dipohusodo, I. (1996b). *Struktur Beton Bertulang*. PT Gramedia Pustaka Utama

[9] ASTM C39/C39M-21. (2021). *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*.

[10] ASTM C496/C496M-17. (2017). *Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens*.

[11] ASTM C78-09. (2009). *Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)*.

[12] Akbardin, J., & Sukma Permadi, G. (2014). KAJIAN PENGGUNAAN FILLER KAPUR PADA AC-WC HALUS SPESIFIKASI JALAN BINA MARGA 2010. ASTONJADRO, 3(2), 43–51. https://doi.org/10.32832/astonjadro.v3i2.814

[13] Yudhistira Baggio, E., Hartono Bagio, T., & Tistogondo, J. (2023). Mix Design Programming for Normal Concrete using Cubic Equation. ASTONJADRO, 12(1), 77–85. https://doi.org/10.32832/astonjadro.v12i1.7143

[14] Sulkarnain, S., Erniati, E., Gusty, S., Ritnawaty, R., Ashraf, A., Huda, M., & Putri, H. R. (2024). Effect of fine modulus of coarse aggregate on the mechanical properties of concrete submerged in sea water. ASTONJADRO, 13(2), 397–406. https://doi.org/10.32832/astonjadro.v13i2.14907

[15] Astariani, N. K., Eka Partama, I. G. N., & Dwi, I. G. A. R. C. S. (2023). Influence Substitution of Tabas Stone Waste which Coated Polyester Resin to Concrete Compressive Strength. ASTONJADRO, 12(3), 738–745. https://doi.org/10.32832/astonjadro.v12i3.9065

[16] S Syaiful, H Rusfana. (2022). Rigid Pavement Planning in Traffic: Case Study in Ciherang Road and Pemuda Road, Bogor Regency, INDONESIA. Journal of Applied Engineering Science 20 (2), 485-497.